WAWONA TUNNEL
Yosemite National Park Roads and Bridges
Through Turtleback Dome on Wawona Road
Yosemite National Park
Mariposa County
California

HAER NO. CA-105

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

REDUCED COPIES OF MEASURED DRAWINGS

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
U.S. Department of the Interior
P.O. Box 37127
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HISTORIC AMERICAN ENGINEERING RECORD

WAWONA TUNNEL
Yosemite National Park
HAER No. CA-105

I. INTRODUCTION

Location: Wawona Road (South Entrance Road, California Highway 41) through Turtleback Dome, 1.7 miles west southwest of Yosemite Valley.

UTM: A: 11/262650/4177650
B: 11/264225/4177525
C: 11/264225/4177275
D: 11/262650/4177400

Quad: El Capitan, CA

Date of Construction: 1931-32.

Designer and Builder: U.S. Department of Agriculture, Bureau of Public Roads: Dr. L. E. Hewes, Deputy Chief Engineer; C.H. Sweetser, District Engineer; Levant Brown, Senior Highway Engineer; Harry S. Tolen, Supervising Engineer; T.M. Roach, Resident Engineer.

Contractor: Goerig & Dahlberg, Inc.

Original and Present Owner: Yosemite National Park, National Park Service.

Present Use: Vehicular Tunnel.

Significance: The longest vehicular tunnel in the western United States at the time of construction, the Wawona Tunnel is significant for minimizing the negative effects of road construction on the Yosemite landscape.

Project Information: This document was prepared as part of the 1991 Historic American Engineering Record "Yosemite Roads and Bridges Recording Project," conducted in summer 1991 by the Historic American Engineering Record.

Richard H. Quin, Historian

II. HISTORY

This is one in a series of reports prepared for the Yosemite National Park Roads and Bridges Recording Project. HAER No. CA-117, YOSEMITE NATIONAL PARK ROADS AND BRIDGES, contains an overview history of the park roads. In addition, HAER No. CA-148, WAWONA ROAD, contains more specific information on the road on which the Wawona Tunnel is located.

History of the Wawona Tunnel

The Wawona Tunnel, the major engineering feature of the $2 million Wawona Road, was the longest vehicular tunnel in the western United States upon its completion in 1932. The 4,230' tunnel carries the Wawona Road (South Entrance Road, California Highway 41) through Turtleback Dome 1.7 miles west southwest of the Yosemite Valley. Relocation of the route through the tunnel guaranteed a minimal impact on the Yosemite Valley landscape and created a major new vista for visitors entering the park from the south.

In 1926, National Park Service Director Stephen Mather authorized a study for improvements to the overburdened road system in Yosemite National Park. In 1928, he announced plans for the reconstruction of the Wawona Road. Henry S. Tolen, Supervising Engineer for the Bureau of Public Road's San Francisco office, spent the next two years working out a new course for the road. Tolen determined that the existing route, which climbed from Grouse Creek over Turtleback Dome before making a steep descent to the Valley, had too severe a grade for modern traffic, and suggested a vehicular tunnel below Turtleback Dome as a solution.[1]

Several alternatives were studied and rejected. These included a new road blasted out of the side of Turtleback Dome, a bypass road beneath Bridalveil Fall, and a series of sharp switchbacks down the steep cliffside. National Park Service planners, assisted by some of the Nation's leading landscape architects and engineers, determined that these proposed routes would cause irremediable scars which would produce appalling effects on the Valley landscape. As a result, the proposed tunnel route was adopted.

The first consideration was for a 1,400' tunnel above the present location. However, the planners decided that the extensive approach cuts would produce far too great an amount of excavated material, some of which would inevitably end up in the Merced River, further restricting stream flow and causing potential flooding problems. After further study, Yosemite National Park Superintendent Charles Goff Thomson announced that a 4,230' tunnel at a lower elevation had been chosen. Surprisingly, the longer tunnel was expected to cost less, as the amount of excavated rock to be removed was much reduced.

The new tunnel route was controversial. Many critics did not want to abandon Inspiration Point and its cherished view of Yosemite Valley. Among these were Horace Albright, Assistant Director of the National Park Service, and NPS Chief Engineer F. A. Kittredge. But Engineer Tolen had 27 men inspecting

possible alternative routes over and through Turtleback Dome, and reported the tunnel route would be the least obtrusive route for the reconstructed road. Following Tolen's report, the tunnel plan was adopted.[2]

The Bureau of Public Roads supervised the construction, which was done by contractor Goerig & Dahlberg of Seattle, Washington. The work began on 30 January 1931. By the end of the month, the contractor had completed 80 percent of the clearing of the accompanying section of road, which extended from Turtleback Dome to the Valley floor, and had constructed a pioneer road for 1 1/4 miles toward the east portal. At the tunnel itself, a 10' x 10' heading had been driven for 25', but work on the main bore had not begun. Equipment used on this phase of the project included one 1 1/2 cubic yard air shovel, two trucks, a truck hoist, and a 1000 h.p. compressor with an electric motor; 57 men were employed in the preliminary work.[3]

The tunnel was bored through solid granite and was originally unlined except in sections where rock failures necessitated a concrete lining. The tunnel was bored from the east, or lower, end only, with the excavated rock used as fill for the new approach road from the Valley, and for the construction of two parking areas and vistas outside the east portal.

The tunnel's site was given much attention. The location of the west portal was fixed by surveys for the section of the road between Grouse Creek and Turtleback Dome, already under construction. The east portal, however, was placed to provide the best view of Yosemite Valley and allow for parking areas for visitors that stopped to enjoy the vista. The tangent was chosen with the approval of NPS Junior Landscape Engineer John B. Wosky.[4]

By March, the preparatory work was complete, and the main bore was begun; by the end of the month it was driven in for 220'. The company had 100 men working on the project. By the end of April, Goerig & Dahlberg had extended the tunnel to the 690' mark, and a subcontractor was installing stone retaining walls along the road edge on Turtleback Dome. Two battery-powered locomotives and twenty dump cars were employed to move the excavated rock. Other additional equipment in use included a second truck, a second compressor, steel sharpeners and various small tools. Inspector J. L. Mathias of the Bureau of Public Roads, visited the tunnel and pronounced the work satisfactory.[5]

In May, the work force on the project reached 187 men, and an additional six trucks were put into use. The tunnel bore reached 1,100', and the east approach road was fully graded. Employment reached a peak of 200 men in June, and by the end of the month the tunnel bore had been extended to 1,575'. The longest weekly advance, 136', was in June, and by the close of the month a the half-way point was crossed, with the tunnel reaching 2,085'.[6]

To facilitate the work, an electrical line was brought up the cliffs from the park powerhouse on the Merced River, and two air compressors were used for drilling holes for the explosives.[7] Ingersoll-Rand heavy liner drills were used, one with a 2" starter bit and the other with a 1" bit for finish work;

these bored on average one foot in minute and a half.[8] The average daily progress was 20′ per day. In the course of construction, 85 tons of drill steel was worn out, crews using some 5,000′ of steel per shift. The blasting crews used 275 tons of Hercules powder in shots averaging one ton each. During the project, some 100,000 tons of rock was removed.[9] A temporary mine railroad was installed to handle the excavated material and to provide transportation for workers and machinery.[10] The construction camp was located near the present parking area for Bridalveil Fall.[11]

The 3,000′ mark was reached in late September, the contractor working ahead of schedule. At the end of October, the bore was in to 3,454′. Work was now underway on the parking areas at the east end of the tunnel, and the road across Turtleback Dome on the west side was complete. In November, work began on the first of the ventilation adits. By the end of the year, only 30′ remained for the main bore. In December, however, a portion of the tunnel roof collapsed 400′ in from the west portal, at a point at which the tunnel passed under a gulch. The hole was sealed with a rock retaining wall and cement patch.[12]

The tunnel bore was completed on 6 January 1932, and work began immediately on the three ventilation adits and on trimming the rock from the main bore. By February, the adits were progressing at 10′ per day. The two side adits were complete by the end of March, and the central adit was finished in April. Forms for the tunnel lining were constructed in May, and the lining work began in June. At this point, a decision was reached to enlarge the central adit to allow space for ventilation equipment.[13]

Goerig & Dahlberg, the main tunnel contractors, received the $37,640 contract for the central adit enlargement on 12 May 1932. The company used four drills with water leyners, then blasted out the rock. The excavated material was used on the east tunnel grade and on the approaches to the new El Capitan Bridge, under construction in the Valley. The adit enlargement was completed on 15 July at a cost of $39,640.21. It was then lined with reinforced concrete.[14]

United Concrete Pipe Corporation paved and lined the tunnel under a $110,822 contract awarded 31 August 1932. Stone from the rock crusher at the borrow pit near Pohono Bridge was used for the base coat of the pavement, and a bituminous asphalt was used as the top coat. The final pavement was seven inches of class A Portland cement concrete, poured in 2′ x 10′ and 2′ x 2′ strips. The class A reinforced concrete lining was poured in 20′ sections. Movable wooden forms, reinforced by timber cribs, were used to form the 14′ radius intrados, which had sides 18″ thick and a 15″ crown. A 10″ x 12″ concrete curb was placed along each side, and a 3′ concrete sidewalk along the north or outer side; this sidewalk had a concealed channel for drainage and to carry high voltage lines from the power house to the ventilation adit. Reinforced concrete drainage boxes with metal grates were installed at both portals. United Concrete also constructed the curbs and steps for the parking areas, taking stone for this work from a quarry near the powerhouse dam. The

tunnel paving and lining work was completed and accepted on 5 January 1933, fifteen days behind schedule.[15]

The tunnel was provided with the three fresh-air adits or openings to provide for natural ventilation. However, it was determined that natural circulation would not sufficiently void the tunnel of toxic carbon monoxide (CO) gas, emitted by internal combustion engines. To ensure motorists' safety, the National Park Service engaged S. H. Ashe, District Engineer for the U.S. Bureau of Mines, to plan an adequate ventilation system. Ash specified a system utilizing three large ventilation fans in the enlarged central adit. The fans would be activated by carbon monoxide detectors connected to sensors at the upper and lower ends of the tunnel. The automatic equipment would detect minute traces of gas in the tunnel atmosphere, and were so sensitive that, when one part CO per 20,000 parts of tunnel air was registered, one of the three 9' fans was activated. Higher percentages would cause additional fans to engage, so that if a dangerous six parts per 20,000 were detected, all three fans would be operating at high speed, exhausting the tunnel air at 300,000 cubic feet per minute. At the same time, semaphores at the tunnel ends would drop to halt traffic from entering, and warning klaxons would sound. The two side adits would allow passengers to escape to the cliff face, and telephones were installed for emergency use.[16] The ventilation fans were installed by the J. Herman Co. and were accepted on 28 March. Mine Safety

Appliances installed the analyzing equipment in the spring of 1933 *; it was operational on 25 March and accepted by the Park Service on 8 April.[17]

Power to the tunnel was provided from the National Park Service power plant on the Merced River below, and was conducted to the tunnel on an 8,000' transmission line borne by steel poles. At the crest, the lines were laid in an underground vault beneath the sidewalk and travelled 2,300' to the ventilation adit. There, transformers reduced the 2,300-volt power to 1,065 volts for the tunnel's 20 ampere series lighting system, and to 220/110 volts for the ventilation fan motors. The transmission line was completed on 24 March 1933. The electric lighting system was installed by W. B. Baker & Co. in the winter of 1932-33; the system used a series array of 4,000 lumen lights, with 6,000 lumen lights near the portals to create a daylight transition effect.[18]

Goerig & Dahlberg of Seattle, Washington (after April 1932, the A. C. Goerig Company), was the main contractor for the $690,000 project, which also included the parking areas and approaches. The following table breaks down

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* HAER recorded the following equipment in the ventilation adit in July 1991:

Three Allis-Chalmers Manufacturing Company (Pittsburgh, PA) distribution transformers, rated at 50 Kv, 60 cycle, 1925 patent series [original];

Two Sorgel 3-phase transformers, manufactured by the Square D Company (Milwaukee, WI), rated at 112.5 Kv, producing 27 amperes [replacement];

Two Square D mini break switches, rated at 5 Kv, with a basic impulse level of 60 Kv and a fuse range of 30-200 amperes [replacement]; and

One smaller Allis-Chalmers transformer, rated for 2,200 volts, 60 cycle [original].

The Mine Safety Appliances "Carbon Monoxide Alarm and Recorder" can detect up to 0.10% carbon monoxide in the tunnel air. The monitor works on the conversion of carbon monoxide (CO) to carbon dioxide (CO_2). Air is drawn from the two sampling stations, filtered, adjusted for barometric pressure, and injected through a detector cell containing active Hopcalite, a catalyst, which causes the oxidation of the CO in the sample, producing CO_2. Heat liberated by the oxidation is measured by a recording potentiometer as a percentage of CO. When carbon monoxide levels reach a set level, the fan controls are engaged or alarms activated. This equipment has been upgraded and has several replacement units.

In theory, this is how the system works. However, the carbon monoxide recorder has been disconnected since September 1989, and the fans are now run continuously, one at a time. The ventilating system is scheduled for replacement in 1993.

projected contractual cost of the tunnel approach and lists the major subcontractors:

Paving	United Concrete Pipe, Inc. .	$117,000
Electrical equipment	W.B. Baker & Co., Inc.	18,000
Power line	City Improvements, Inc. . . .	9,000
Carbon monoxide recorders	Mine Safety Appliances, Inc. .	9,000
Ventilating fans	J. Herman Co.	4,500

The project was let out to the contractors on 13 November 1930, and work was completed on 13 April 1933, without a person killed or seriously injured.[19] Actual construction costs were:

Carbon monoxide recording equipment	$10,061.49
Ventilating fans, motors, transformers, etc.	8,394.95
Lighting system	6,440.89
Switchboard, relays, controllers, etc.	2,184.00
Telephones, cables, line, etc.	1,913.00
Warning signals, line, etc.	1,555.00
Transmission line, power panel, etc.	9,144.00
TOTAL COMPONENT COSTS	$39,693.39

TOTAL TUNNEL CONSTRUCTION COSTS (excluding parking, etc.) $563,729.31[20]

The tunnel grade is 5 percent, and that of the approaches 6 percent, with a transverse grade of 2" to the north per 24' of road. The maximum depth of the rock above the tunnel is 550', and the maximum distance in from the cliff 503'. The tunnel is 28' wide and 19' high (measured from the roadway).

Formal dedication ceremonies for the tunnel were held 10 June 1933. Secretary of the Interior Harold Ickes addressed the crowd of 4,000 by telephone over a public address system provided by the Standard Oil Company. A letter was read from President Franklin Roosevelt. The National Park Service sponsored a "parade of progress" to mark the occasion; this parade through the tunnel featured local Indians on foot, a group portraying the Mariposa Battalion, prospectors with burros, the first tourist parties on horseback, lumber wagons, stage coaches, motor stages and the latest 1933 automobiles. Galen Clark's carriage, the first in the Yosemite Valley, joined the procession. To actually open up the tunnel, a group of local girls removed a flower garland designed by park artist-in-residence Ferdinand Burgdorff.[21]

Superintendent Thomson spoke of the tunnel's significance to the park landscape:

> The tunnel permits the preservation of the priceless scenic values. At the lower portal the visitor emerges into a view of the incomparable Valley that is fairly explosive in its grandeur, and which a majority of artists and laymen agree surpasses old Inspiration Point. . .

> With the early completion of the Wawona Road, a new era dawns in the southern approach to Yosemite, and the improvement is being accomplished by means of this tunnel, which although spectacular because of the boldness of its conception, was the only engineering solution that guarantees the preservation of the priceless palisades, and the full protection of those incalculable values for which the National Park Service is responsible.[22]

Horace Albright, then Director of the National Park Service, recanted his earlier objections to the tunnel route and stated "No one will miss Inspiration Point."[23]

New views of the Yosemite Valley were provided to visitors by two turnouts outside the east tunnel portal. These parking areas, built in part on fill blasted from the tunnel core, are perhaps the most popular view in Yosemite National Park. Called "Tunnel View" by the National Park Service and "Discovery View" by the Board of Geographic Names,[24] the turnouts present the visitor with stunning views of the "incomparable Valley" dominated by Half Dome, Bridalveil Fall, Sentinel Rock and El Capitan.

Park landscape planners strove to design the tunnel to blend into the mountainside as unobtrusively as possible. No cut stone decorates the east portal, which is highly visible from the parking vista. The west portal, with no parking area, is a continuation of the reinforced concrete barrel vault; in an effort to minimize its intrusive appearance, this portal and the surrounding rock cuts were painted with a mixture of lamp black, linseed oil and mineral spirits. A total of 1,059 square yards of cut granite was covered. Road cuts around the tunnel and on the approaches were landscaped with native plantings placed by workers from the Civilian Conservation Corps.[25]

The tunnel was unlined except in sections where loose rock posed problems; these areas were lined with reinforced concrete. However, disintegration of surface rock caused by water seepage and air slacking soon began to occur. In 1934, nearly $4,000 was spent removing loose rock. To deal with the problems, in 1935 the BPR authorized a stabilization program in which the interior tunnel surfaces were shotcreted with gunite, a pneumatically-applied mortar coat. The guniting was begun by Peninsula Paving Company with 25 men on 17 April and completed on 23 May. At the same time, construction crews widened the entrances to the parking areas and placed a small stone retaining wall over the east portal, its purpose being to divert water from dripping over the tunnel entrances. Total cost of the project was about $22,000.[26]

In 1934, Curry Company auto stage drivers were noted stopping their vehicles in the tunnel and revving their engines to make the fans cut on; they were ordered by NPS officials to halt the practice.[27] A blinking yellow warning light was added in 1938 to try to slow cars down as the exited the lower end of the tunnel at the turnout to "Tunnel View."[28] This remains a dangerous spot, and multiple fatality accidents have occurred here.

By 1955, the National Park Service was concerned about water dripping from the tunnel ceiling. This brought complaints from motorists, especially those with convertibles. Superintendent John Preston warned that the situation was causing icicles to form at the tunnel portals, and posed a real source of danger to motorists. The Bureau of Public Roads responded by designing additional linings, and placing by derrick a new retaining wall over the east portal, supplemented by electric heating cables designed to melt off the ice that might accumulate.[29] The old series lighting system was replaced in 1984 with high-pressure sodium fixtures.

During the Cold War era, the central adit was stocked with emergency supplies to allow the tunnel to serve as a fallout shelter. Water, cots and other supplies were kept stocked into the 1970s; most of the stores have since been removed.

Water dripping from the east portal remains a problem. As recently as 1984, the Federal Highway Administration recommended that a concrete portal similar to that on the west end be constructed, disregarding the care taken to fit the tunnel in with the popular parking vista. This suggestion was repeated in a Bridge Safety Inspection Report filed on the tunnel in 1986, along with recommendations for installing a backup system for the ventilation fans, rumble strips to slow traffic exiting the tunnel and minor repairs.[30] These changes had not been implemented as of 1990.

The Wawona Tunnel is the most significant road structure in the Yosemite National Park, and the accompanying parking vista remains one of the most popular views of the Yosemite Valley. Little changed since its dedication, the tunnel demonstrates the care the National Park Service and the Bureau of Public Roads showed in the design of the early segments of the park's modern road system, as it integrates the new Wawona Road into its surrounding landscape, avoiding great disfigurement of the Yosemite Valley walls.

III. ENDNOTES

1. Hank Johnston, *Yosemite's Yesterdays* (Yosemite, CA: Flying Spur Press, 1989), 45.

2. *Ibid.*, 45; F. A. Kittredge, Chief Engineer, NPS, to F. E. Mathes, U.S. Geological Survey Survey, 3 April 1929. Yosemite Research Library.

3. Charles G. Thomson, Superintendent's Monthly Report, January 1931, 7.

4. Bureau of Public Roads, "Location Survey Report on the Wawona Road, Turtleback Dome-Valley Floor section, Yosemite National Park," n.d., 2-3.

5. Thomson, Superintendent's Monthly Report, March 1931, 8; Superintendent's Monthly Report, April 1931, 14.

6. Idem, Superintendent's Monthly Report, June 1931, 22; Superintendent's Monthly Report, July 1931, 9.

7. "Yosemite By Tunnel Approach," *Standard Oil Bulletin*, 1932, n.p.

8. Frederick Black, Supervising Engineer, Bureau of Public Roads, to Harry S. Tolen, Engineer, Bureau of Public Roads, June 1934. Yosemite Research Library.

9. "Information on the Construction of the Wawona Tunnel, Based on Statements from Mr. Henry S. Tolen," typed MSS, 5 April 1948, 5-6. Yosemite Research Library.

10. T. E. Connelly, Jr., "Rockne Visits New Wawona Tunnel," (Stockton) *Daily Independent*, 31 January 1932, 8.

11. Agnes McGee, "Society Ed. Dines with Construction Crew," (Stockton) *Daily Independent*, 31 January 1932, 8.

12. Thomson, Superintendent's Monthly Report, September 1931, 13; Superintendent's Monthly Report, October 1931, 8; Superintendent's Monthly Report, December 1931, 7.

13. Idem, Superintendent's Monthly Report, January 1932, 8; Superintendent's Monthly Report, February 1932, 6; Superintendent's Monthly Report, March 1932, 6; Superintendent's Monthly Report, April 1932, 8; Superintendent's Monthly Report, May 1932, 7; Superintendent's Monthly Report, June 1932, 8.

14. T. M. Roach, Bureau of Public Roads, "Final Construction Report, Wawona Tunnel Adit Enlargement," 3-4.

15. Roach, "Final Construction Report, Wawona Road Surfacing, Turtleback Dome-Valley Floor, 18 July 1933," 3-6, 10-13; Thomson, Superintendent's Monthly Report, January 1933, 2, 5.

16. "Information on the Wawona Tunnel," 5-6.

17. Thomson, Superintendent's Monthly Report, March 1933, 8; Superintendent's Monthly Report, April 1933, 9.

18. Raymond Archibald, District Engineer, to Olie Singstad, Singstad & Baille, n.d., Yosemite Research Library (Singstad & Baille were contracting to build vehicular tunnels in Norway, and contacted Archibald for information on the Wawona Tunnel.); Thomson, Superintendent's Monthly Report, March 1933, 8-9.

19. Charles G. Thomson, "Summarized Information, Wawona Tunnel." Typed report to the Secretary of the Interior, 10 June 1933. Yosemite Research Library.

20. Archibald to Singstad, 6.

21. National Park Service program brochure, "Dedication Yosemite-Wawona Tunnel, Pageant of Progress," 10 June 1933; National Park Service press release, "Dedication 'Pageant of Progress,'" 7 June 1933, Yosemite Research Library; Yosemite National Park press release, attached to Thomson, Superintendent's Monthly Report, May 1933; Thomson, Superintendent's Monthly Report, June 1933, 17.

22. Quoted in Johnston, 46. Thomson, as Superintendent, had overseen construction of the new road and the tunnel, and drove the first car through the newly-completed bore several months earlier. On his death in March 1937, the Park Service held a memorial service for him at Tunnel View. (John B. Wosky, Acting Superintendent's Monthly Report, March 1937, 1.)

23. "Information on the Wawona Tunnel," 4.

24. National Park Service, "Yosemite—Official Map and Guide," 1990 reprint; U.S. Geological Survey, El Capitan, CA quadrangle, 7 1/2 minute series, 1991.

25. Robert Charles Pavlik, "In Harmony with Nature: A History of the Built Environment of Yosemite National Park, 1915-1940," (Master's thesis, University of California at Santa Barbara, 1986), 60.

26. Linda Wedel Greene, National Register of Historic Places nomination, Wawona Tunnel, March 1989, Sec. 8, 2-3; Bureau of Public Roads, Division 7, San Francisco, "Memorandum for Project Yosemite 2-A5, Tunnel Drainage and Slope Stabilization," 18 April 1935, 1-2; Thomson, Superintendent's Monthly Report, April 1935, 7; Superintendent's Monthly Report, May 1935, 9.

27. Thomson, Superintendent's Monthly Report, August 1934, 6.

28. Lawrence C. Merriam, Superintendent's Monthly Report, January 1938, 4.

29. John C. Preston, Park Superintendent, to Herman P. Cortelyou, 18 July 1955; Memorandum, Superintendent Preston to NPS Assistant Director for Region IV, n.d. Copies in Yosemite Research Library.

30. Department of Transportation, Federal Highway Administration, Bridge Safety Inspection Report, Wawona Tunnel (Denver, CO: FHwA Office of Western Bridge Design, May 1984), E1, H.; Idem, *Bridge Safety Inspection Report, Wawona Tunnel* (Denver, CO: FHwA Bridge Design Division, September 1986), 3-6.

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